HYDRAULIC FLUIDS

FIELD OF THE INVENTION

This invention relates to hydraulic fluids, and in particular, but not exclusively, to hydraulic fluids for use in the offshore oil and gas industry.

BACKGROUND TO THE INVENTION

When drilling for subsea oil, it is normal for a drilling rig to drill a hole in the seabed in search for the oil reserves. After drilling down a specified distance, it is common to place a BOP stack on the wellhead on the seabed and then continue to drill through the center of the BOP unit. The Blow-Out Preventor (BOP) stack is in simple terms, a hydraulically operated safety device that can shut down the well if a gas pocket or oil is discovered (a blow out). The unit works by hydraulic pressure that can be used to seal the gap between the drill string (which turns the head of the drill and connects to the drilling rig) by either forming a seal against the drill string or slicing through the drill string in more dangerous situations. The sealing and slicing operation is conducted by hydraulic pressure which forces large hydraulic rams to close; the fluid is then released to sea to relieve the pressure after operation.

The BOP Stack and hydraulic control pods that are on the seabed (or sometimes on board the rig if drilling in shallow water) are connected by a hydraulic hose (Umbilical) to the rig where operation can be controlled via a control panel by rig operators.

The hydraulic system has a large hydraulic fluid reserve tank on board and as the fluid is pressurized and then dumped to sea, the fluid is removed from the reserve tank.

Many BOP stacks utilize Type-One BOP hydraulic fluid, which is an aqueous hydraulic fluid concentrate, minus the water (and antifreeze if required).

In a bid to minimize the amount of space required to store the hydraulic fluid on board, rig operators tend to take a supply of the water hydraulic fluid as a concentrate without the water and antifreeze present and then add water and antifreeze on board as required.

Some rigs prefer premixed fluid in some areas for different reasons and that is supplied in a similar manner as that outlined in Type Two below.

Other Operators Utilize Type Two- Production Control Hydraulic Fluids.

This type of water based hydraulic fluid is typically a premixed version of the BOP Fluid mentioned above, sometimes with additional antifreeze and stability additives as required.

This premixed fluid is used to produce oil remotely via a system whereby a subsea hydraulic control system is placed on the wellhead and linked back via a hydraulic umbilical to the producing asset (fixed platform, floating unit or to land).

The system is similar in many ways to the BOP system although in this case the functions at the wellhead control the flow of oil and other production related functions and typically use much smaller valves with greater tolerances and greater need for stability, fluid cleanliness etc.. In addition, the umbilical hydraulic line can be of varying lengths from a few kilometers to several hundred kilometers.

There is a Third Type of BOP Hydraulic Fluid, Type Three- Water Based ISO Equivalent Hydraulic Oils.

These fluids are based on the same technology as the other fluids described above and usually comprise of the base Type Two Production Control Fluid described above with added thickening agents to match the ISO hydraulic oil in use.

Many applications on board drilling and production units use standard ISO hydraulic oils, with varying viscosity dependent on application.

Typical performance requirements for offshore hydraulic fluids include

1. Lubricity- it is important that a water based hydraulic fluid has sufficient lubricity to allow moving surfaces (such as metal to metal contacts within valves), to slide without sticking or wearing outside of acceptable limits.

2. Corrosion Protection- it is important that a water based hydraulic fluid has sufficient corrosion

protection to protect the metals in the system from corrosion, especially if moderate seawater ingress is likely.

3. Stability additives- it is important that a water based hydraulic fluid has sufficient stability to ensure the fluid does not separate in service. The level of importance of this depends on the application as some systems are very prone to such issues. If a product does not have sufficient stability in its own right, it is common to use some form of chemical additive that will ensure the product does not separate.

4. Biocidal Protection- it is important that a water based hydraulic fluid has sufficient biocidal protection to prevent excessive growth of fungus and bacteria within the hydraulic fluid medium.

5. Elastomer Compatibility- it is important that a water based hydraulic fluid does not adversely affect the elastomers present within the system.

6. Antifreeze Protection- it is important that a water based hydraulic fluid has sufficient antifreeze protection to allow the product to be used in cold conditions.

7. Viscosifiers- Some fluids may need to have their viscosity modified to match a certain technical profile, this would involve adding additives to increase or decrease the viscosity of the product.

8. Environmental Acceptability- it is important that a water based hydraulic fluid is sufficiently environmentally acceptable to allow its discharge under the individual regulations in place for each applicable country under whose legislation the drilling occurs.

It would be advantageous to provide an aqueous based hydraulic fluid which did not include large quantities, or indeed any quantity of oil, especially mineral oil or synthetic hydrocarbon oil, which oils create environmental problems especially in offshore applications.

It would furthermore be advantageous to provide aqueous hydraulic fluids which include environmentally friendly lubricants, which lubricants do not rely on mineral or synthetic hydrocarbon oil formulations in order to work effectively.

It is therefore an aim of preferred embodiments of the present invention to overcome or mitigate at least one problem of the prior art, whether expressly disclosed herein or not.

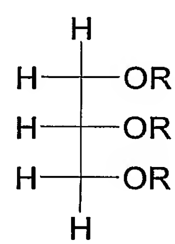
SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided an aqueous hydraulic fluid comprising, in addition to water, at least one phospholipid lubricant, wherein the hydraulic fluid comprises less than 20% by weight of an oil selected from a mineral oil, a synthetic hydrocarbon oil or any mixture thereof.

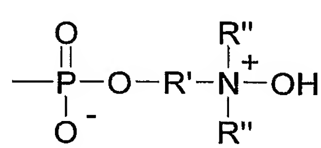
Suitably the aqueous hydraulic fluid comprises water in an amount of at least 10% wt, preferably at least 20% wt, and more preferably at least 30% wt of the total weight of the hydraulic fluid. Suitably the aqueous hydraulic fluid comprises water in an amount of no more than 95% wt, preferably no more than 90% wt, more preferably no more than 80% wt and most preferably no more than 75% wt of the total weight of the hydraulic fluid.

A preferred concentration of water is substantially 30-70% wt of the total weight of the hydraulic fluid.

Preferably the phospholipid lubricant comprises a phosphatide, especially having a structure



wherein at least one R is a phosphorus containing group having the structure



and at least one R is a fatty acyl group;and

wherein R′ is independently an alkyl group preferably independently having from 1 to 12 carbon atoms and R″ is

an alkyl group preferably independently having from 1 to 8 carbon atoms, more preferably from 1 to 4 carbon atoms.

The fatty acyl group is preferably derived from a fatty acid having between 4 and 30 carbon atoms, such as octanoic acid, stearic acid, oleic acid, palmitic acid, behenic acid, myristic acid and oleosteric acid, for example.

Preferably one R group is a phosphorus containing group and two R groups are fatty acyl groups.

Preferred phosphatides are phosphatidylcholine, phosphatidylinositol, phosphatidylserine, and phosphatidyethanolamine.

There may be more than one phospholipid and preferably more than one phosphatide. For example the hydraulic fluid may comprise phosphatidylcholine, phosphatidylinositol and phosphatidylethanonamine.

The total concentration of the phospholipid lubricants preferably comprises at least 0.1% wt of the total weight of the hydraulic fluid, more preferably at least 0.5% wt, and most preferably at least 1% wt. The phospholipid lubricant preferably comprises no more than 30% wt of the total weight of the hydraulic fluid, more preferably no more than 25% wt and most preferably no more than 20% wt. In preferred hydraulic fluids the total weight of the phospholipid lubricant comprises substantially 0.1-20% wt of the total weight of the hydraulic fluid.

Especially preferred phospholipids are those derived from commercial fatty compounds such as soybean oil, cotton seed oil and castor seed oil.

A particularly preferred effective mixture of phosphatides and other phospholipids is found in soybean lecithin and other plant-derived lecithins. Plant-derived lecithins generally comprise a mixture of phosphatides, phospholipids and natural oils, in addition to other ingredients such as carbohydrates.

In preferred embodiments, the hydraulic fluid comprises a plant-derived lecithin, such as soybean lecithin, castor lecithin, *rapeseed* lecithin, cotton seed lecithin and the like, for example. Especially preferred is soybean lecithin, preferably comprising soybean oil, phosphatidylcholine, phosphatidylethanolamine, and phosphatidyinositol.

The plant-derived lecithin lubricant preferably comprises at least 1% wt of the total weight of the hydraulic fluid, more preferably at least 2% wt, and most preferably at least 4% wt. The plant-derived lecithin lubricant preferably comprises no more than 60% wt of the total weight of the hydraulic fluid, more preferably no more than 50% wt and most preferably no more than 40% wt. In preferred hydraulic fluids the total weight of the plant derived lecithin lubricant comprises substantially 1-30% wt of the total weight of the hydraulic fluid.

It is preferred that the phospholipid, mixture of phospholipids or, especially, plant derived lecithin is substantially the sole lubricant in the hydraulic fluid,

but in some embodiments the hydraulic fluid may comprise additional non-phospholipid lubricants. Suitably non-phospholipid lubricants include C_6-C_{30} organic acids, heavy metal compounds, phosphate esters, sulphur complexes and water soluble or partially soluble esters. Preferred embodiements of the invention comprise one or more lecithins, which include one or more phospholipids lubricants, in addition to other lipids, natural oils and the like.

The phospholipid lubricant and/or any additional lubricant present may also serve to function as a corrosion inhibitor. Alternatively or additionally the hydraulic fluid may comprise at least one separate corrosion inhibitor. The corrosion inhibitor may comprise an alkylamine or alkanolamine. Suitably alkylamines preferably comprise a C_6-C_{20} linear or branched alkyl group. Suitable alkanolomines preferably comprise 1 to 12 carbon atoms, more preferably 6 to 9 carbon atoms. The alkanolamine may comprise more than one alkanol group, for example dialkanolamines and trialkanolamines. Preferred alkanolamines include monoethanolamine and triethanolamine. Other corrosion inhibitors include copper corrosion inhibitors such as benzotriazole, for example.

The hydraulic fluid may include a stabiliser. Many preferred embodiments of the hydraulic fluid of the invention do not require stabilisers, as they are stable in their own right. However certain additives and ingredients may be unstable in the hydraulic fluid for a variety of reasons, such as ingredients which are insoluble or only partially soluble in the aqueous media

of the fluid, or ingredients and ions which form complexes with hard water salts. Therefore the particular stabiliser or stabilisers used may depend on the other ingredients present in the hydraulic fluid and/or the hardness of the aqueous media used in the fluid. Suitable stabilisers include surfactants, which may effect increased solubility of ingredients in the hydraulic fluid. Suitable surfactants include ethoxylate surfactants. Another suitable type of stabiliser is a complexing agent, which is able to complex with ions or ingredients that may react with hard water salts in the aqueous media. Suitable complexing agents include EDTA. The hydraulic fluid may contain a biocidal additive. Biocidal additives useful in the hydraulic fluids of the invention, include sulphur-containing biocides and nitrogen-containing biocides. Suitable nitrogen-containing biocides include triazenes and guanidines.

The hydraulic fluid may comprise an antifreeze additive. In some embodiments a high concentration of the dissolved or suspended ingredients of the aqueous hydraulic fluid can provide sufficient antifreeze effect without the need for additional anti-freeze additives. If an antifreeze additive is needed in the hydraulic composition it is preferably a glycol compound, glycerol, or a glycerol ester. Suitable glycols include alkylene glycols, preferably having 1 to 12 carbon atoms in each alkylene group, which groups may be linear or branched. The alkylene glycols may be monoalkyleneglycols or dialkleneglycols. Preferred glycols include monoethyleneglycol and monopropyleneglycol, for example.

The hydraulic fluid may comprise further additives such as a viscosity modifier. The viscosity modifier may be an agent capable of increasing the viscosity of the hydraulic fluid or, alternatively may be an agent capable of decreasing the viscosity. The type of viscosity modifier may depend on the application for which the fluid is used, the environmental conditions in which the fluid is used, and other factors. Suitable viscosity modifiers which increase the viscosity of the hydraulic fluid compared to when the modifier is not present, include long chain polymeric compounds such as high molecular weight ethylene oxide/propylene oxide copolymers and high molecular weight polyacrylic acid polymers. Suitable viscosity modifiers which serve to decrease the viscosity of the hydraulic fluid compared to when the modifier is not preset, include organic solvents such as ethylene glycol ethers and propylene glycol ethers.

The aqueous hydraulic fluids of the invention contain less than 20%wt of a mineral oil, synthetic hydrocarbon oil, or any mixture thereof. In order to incorporate oleophilic lubricants into hydraulic fluids, it has been generally necessary to introduce mineral oils or synthetic hydrocarbon oils at a relatively high concentration. The inventors have surprisingly found that aqueous hydraulic fluids can be manufactured which utilises oleophilic phospholipids as a primary lubricant without the need to introduce large, small, or even trace quantities of oils, especially mineral or synthetic hydrocarbon oils. The use of an aqueous base rather than an oil base for the hydraulic fluid also effects superior environmental characteristics to the fluid, especially for applications

such as off-shore and undersea mining and exploration fields.

The use of naturally occurring phospholipids, combined with utilisation of lower quantities of oils further increases the beneficial environmental characteristics of the hydraulic fluids. The applicants have found that the aqueous hydraulic fluids of the invention provide equivalent or superior torque reduction on rotating test members submerged in test fluids, as compared to commercially available oil - containing hydraulic fluids.

Preferably the aqueous hydraulic fluid comprise less than 10% wt of a mineral oil, synthetic hydrocarbon oil or mixture thereof, more preferably less than 5% wt, still more preferably less than 1% wt and most preferably less than 0.1% wt, especially less than 0.01% wt. In especially preferred embodiments the aqueous hydraulic fluid is substantially free of mineral oil and/or synthetic hydrocarbon oil. If an oil is present it is preferably a natural oil, such as a plant-derived oil, for example.

The aqueous hydraulic fluids of the invention are preferably substantially free from phosphorodithioates.

The aqueous hydraulic fluids of the invention are particularly suitable for use as hydraulic fluids in the off-shore, mineral and mining industries.

EXAMPLES

For a better understanding of the invention and to show how embodiments of the same may be put into effect, preferred embodiments of the invention will now be described by the following non-limiting examples: with Reference to Figure 1 which illustrates a graph of the results of a Falex Lubricity Test with respect to hydraulic fluid of the invention compared to known hydraulic fluids.

EXAMPLE 1

An aqueous hydraulic fluid of the invention (Formulation A) was prepared by mixing the following ingredients then homogenising this mixture under pressures of between 500-5,000 psi until a stable dispersion was achieved. The resultant product was then filtered to remove any large particles:

10% w/w Soybean Lecithin, supplied by Cargill PLC, UK
0.1% w/w Benzotriazole, supplied by Ellis and Everard PLC (UNIVAR), UK
0.1% w/w EDTA, supplied by BASF PLC, UK
10% Decanoic Acid(supplied by Multisol, UK)/TEA (supplied by Univar, UK), pre-neutralised salt to pH 8.8
5% w/w Triazene, supplied by Thor Chemicals, UK
40% w/w Monoethylene Glycol, supplied by Ellis & Everard PLC, (Univar), UK
Water to balance

This formulation, hereinafter referred to as Formulation A, is utilised as a BOP hydraulic fluid concentrate that

is diluted by the consumer prior to use, typically to a working concentration of 20% v/v in water and antifreeze mix, dependent on freeze protection required. Formulation A effects excellent torque reduction and anti-wear on off-shore and mining hydraulic apparatus.

Formulation A was investigated using the Falex Lubricity Test, which measures the torque experienced on a rotating test pin submerged in test fluid, as it is subjected to increasing load. Formulation A was tested against two control fluids; Control Fluid 1, a fully synthetic non-phospholipid-containing aqueous based hydraulic and Control Fluid 2, a synthetic hydrocarbon oil based hydraulic fluid.

The experimental protocol and results of the Falex Lubricity Test are given below:

FALEX LUBRICITY TEST

The Falex tester measures the torque experienced on a rotating test pin submerged in the test fluid, as it is subjected to increasing load. The load on the pin is increased at 100lb increments and the torque measured at each load increment. On reaching 500lb load, the load is held for 30 minutes and the level of wear on the test pin recorded in units of 'wear teeth'.

A working version of diluted (20% v/v) BOP Formulation A containing soybean lecithin was compared on the Falex Lubricity Tester to working concentrations of two main control hydraulic fluid products; Control Fluid One, containing synthetic additives but no mineral/synthetic

oils, and Control Fluid Two, containing synthetic hydrocarbon oil.

Comparative torque and wear results for each product are shown in Figure 1 and Table 1 below:

Table 1

Test Data at 500lb Load for 30 mins:

Product	Torque (Lb.In)	Wear Teeth
Formulation A	12	6
Control Fluid 1	13	24
Control Fluid 2	FAIL-PIN SNAPPED	

These results show that Formulation A, compared at working concentrations, exhibits superior torque reduction to a control aqueous based (non-phospholipid containing, non mineral/synthetic hydrocarbon containing) Control Fluid One and superior torque reduction to control synthetic hydrocarbon oil-based Control Fluid Two.

In terms of anti-wear, Formulation A exhibited 25% less wear than Control Fluid One, and Control Fluid Two was unable to withstand the test conditions.

These results show that Formulation A, which is an example of an aqueous hydraulic fluid of the invention, which includes a natural lubricant in the form of soybean lecithin, exhibits more effective torque reduction and anti-wear than the control hydraulic fluids.

In other preferred embodiments of the aqueous hydraulic fluid of the invention, the soybean lecithin may be replaced by an equivalent amount of individual phosphatide, or other natural lecithins. Alternatively

other phospholipids may be incorporated in addition to or in place of phosphatides and lechithins.

The hydraulic fluids of the invention may also include various additives including corrosion inhibitors, stabilisers, biocides, viscosity modifiers, antifreezes and the like.

In preferred embodiments of the hydraulic fluid of the invention, there is no mineral or synthetic hydrocarbon oil present. It may be envisaged that very small amounts of mineral oil or hydrocarbon oil may be present, but these should be kept to a minimum, and no more than 0.01% w/w the total weight of the hydraulic fluid, if possible.

The soybean lecithin used in Formulation A is believed to comprise of the following ingredients:

Soybean oil 37.5%, Phosphatidylcholine 15%, Phosphatidylethanolamine 13%, Phosphatidylinositol 10%, other phospholipids and lipids 19%, and carbohydrate 5%.

EXAMPLE 2

A second preferred embodiment of the aqueous hydraulic fluid of the invention, Formulation B, was prepared by mixing the following ingredients then homogenising this mixture under pressures of between 500- 5,000 psi until a stable dispersion was achieved. Resultant product was then filtered to remove any large particles:

2% w/w Soybean Lecithin
0.01% w/w Benzotriazole

0.01% w/w EDTA
0.5% Decanoic Acid/TEA, pre-neutralised salt to pH 8.8
0.3% w/w Triazene
40% w/w Monoethylene Glycol
Water to balance

The above mentioned formulation is hereinafter called Formulation B.

Formulation B was subjected to the Falex Lupricity Test as described above, and exhibited similar performance to Formulation A. The results showed that Formulation B provided effective water based hydraulic fluid for the off-shore and mining fields.

The aqueous hydrocarbon fluid of the invention exhibit excellent environmental characteristics, and prevent the possibility of accidental release of large quantities of synthetic hydrocarbons or mineral oils into a sub sea environment or water table.

Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination,

except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.